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ASSESSMENT OF HEAVY METALS POLLUTION AND DEGREE OF CONTAMINATION IN THE HEINDA MINING AREA, DAWEI TOWNSHIP

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Abstract

In this research, five soil samples from the mining sites and one from control site from mining works were collected from Heinda mining areas in Dawei Township, Tanintharyi Region in March, 2019. Physicochemical properties of collected soil samples (S_1, S_2, S_3, S_4, and S_5 from the industrial mining sites and undisturbed site (S_0) were determined. All soil samples were nearly neutral in the pH range of 6.32-7.03. Moisture of soil samples were in the range of 0.11- 0.40. Soil types of soil samples were found to be loamy sand for S_0, and sand for S_1, S_2, S_3, S_4 and S_5. In addition, the concentrations of some heavy metals (Pb, Cd, Mn, Zn, Fe, Cu) contents in soil samples were analysed by Atomic Absorption Spectrophotometric method. According to AAS method, Pb contents of soil samples (S_0, S_1, S_2, S_3, S_4, S_5) were not detected. However, Cd contents were observed as 0.05, 0.04, 0.04, 0.07, 0.04, and 0.03 ppm, respectively. Moreover, 6.04, 54.26, 31.42, 19.76, 40.10, and 36.86 ppm of Mn, 0.35, 0.65, 0.69, 0.67, 0.77, and 0.62 ppm of Zn, 39.02,48.02, 49.76, 45.41, 48.06 and 44.46 ppm of Fe and then, 0.50 ppm of Cu was observed for S_0, but not detected for S_1, S_2, S_3, S_4 and S_5. The contamination factor (C_f), degree of contamination (C_d) and pollution load index (PLI) were used to assess the degree of heavy metal pollution in soil. According to PLI, the sites were classified as moderately contaminated with Zn, considerably contaminated with Fe, and highly contaminated with Mn compared to control site.

Keywords: Heinda mining areas, heavy metals, contamination factor, degree of contamination, pollution load index

Introduction

Some heavy metals are either essential nutrients (such as iron, cobalt and zinc), or relatively harmless (such as ruthenium, silver, and indium), but can be toxic in larger amounts (Moe Thu Zar Lwin, 2012). Due to the many anthropogenic activities in industrial areas, soil may get polluted which may cause major heavy metal contaminations and which is more responsible for increasing the pollutants in the soil (Alessio *et al*., 2007). Other heavy metals, such as cadmium, mercury, and lead are highly poisonous. Potential sources of heavy metal poisoning include mining, tailings, industrial-wastes, agricultural-runoff and treated timber (Miller *et al*.,1965).

With the rapid development of mining activities landscape changes as well as environmental pollution have become still more serious (Yao *et al*., 2003). The intense mineral extraction has produced a large amount of waste material accumulated on the heaps or tailings (Ashraf and Ali, 2007). In Myanmar, Heinda Mine is a large old tin mine in the northern part of the Great Tanintharyi River Basin in Tanintharyi Region. The mine is in the proximity of Myitta town and around 45 km away from Dawei city. Current concession area of the tin mine covers around 2,110 acres of land. The area includes three open-pit placer mines Around 2 km downstream from the mining site located “Myaung Pyo” village which is the community most directly and adversely affected by the mining operation.

The Heinda mine is tin ore mine, the pollution from the Heinda mine and wastewater from the mine’s overflowing tailing ponds have contaminated the Myaung Pyo creek, the source of the surrounding communities’ water for drinking, domestic use and irrigation. The wastewater also

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impacts farmland, reportedly damaging the quality of soil. These changes have allegedly caused health problems and disrupted the livelihoods of communities in the area. The communities rely on agriculture, cultivating betel nut, rubber, durian, coconut, vegetables, cashews and bananas to sell. Though the project affected over a dozen villages, one of the most impacted was Myaung Pyo village, located 2 km from the mining site (Gardiner *et al*., 2015). The aim of the study was to determine the level of contamination with heavy metals in this area and to assess the level of contamination using the contamination factor, degree of contamination, and pollution load index.

Materials and Methods

Sample Collection and Sample Preparation

Soil sampling from six sampling sites of Heinda mining area were carried out in March, 2019. Heinda mine is located at 14°7' 52.048" N latitude and 98°26' 12.825" E longitude, Dawei Township, Tanintharyi Region. The total area of Heinda mine is about 2110 acres. The study area and study stations are given in Figure 1.

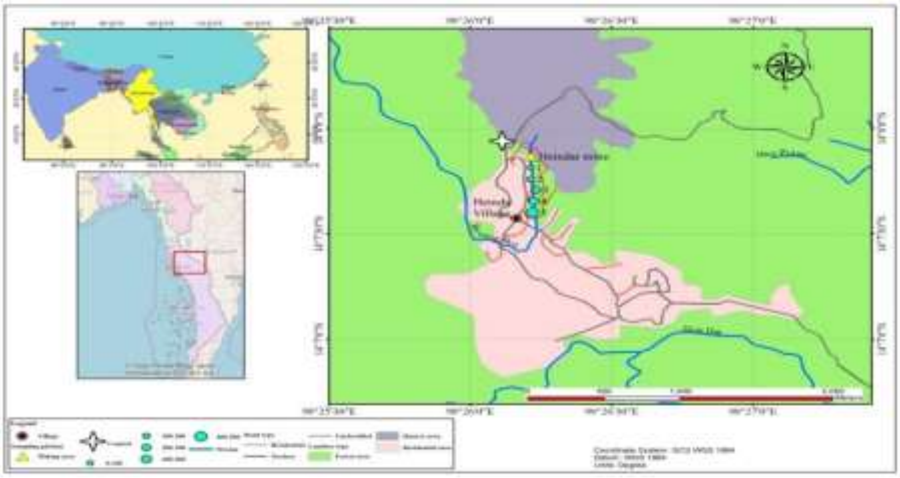

Figure 1 Location of sampling sites on the Heinda mine area

Soil samples were collected from six different stations situated in mining sites and control site of the mining works of Heinda mine. Sampling stations (S_1) was selected within 100 m from the mine and (S_2, S_3, S_4 and S_5) were selected within 100 m of each other. The station, S_0 is the control station, 285 m away, in the north east side of the mining site, and is in a benign environment. The description of the sampling stations is given in Table 1.

Soil samples were taken about 20 cm depth from the surface of the soil. From each sampling site five samples were collected within (2 m × 2 m) square and the collected soil samples were dried in the shade before sieving. Afterwards, the impurities such as gravel, roots, were discarded. Then, these soil samples were ground into fine powder and passed through a 0.2 mm sieve. The soil samples were stored in polyethylene bags and clearly labeled before measurement.

Table 1 GPS and Altitude Information of Sampling Sites on Heinda Mine Area

Sampling Sites	Description	GPS Coordination		Altitude above sea level (m)
		Latitude (N)	Longitude (E)	
S_0	285 m up from work site	14° 7' 56.453"	98° 26' 4.492"	332
S_1	100 m (S) down from site	14° 7' 48.793"	98° 26' 12.833"	267
S_2	200 m (S) down from site	14° 7' 45.538"	98° 26' 12.826"	265
S_3	300 m (S) down from site	14° 7' 42.486"	98° 26' 13.986"	260
S_4	400 m (S) down from site	14° 7' 39.274"	98° 26' 13.446"	258
S_5	500 m (S) down from site	14° 7' 36.035"	98° 26' 13.119"	256

Physicochemical Analysis of Soil Samples

Six soil samples were obtained from six sampling sites of Heinda mine. Some physicochemical parameters of soil samples were determined by using the following procedures. An appropriate clean porcelain crucible was dried and then weighed. A 1 g of accurately weighed air-dried sampling soil was placed in the crucible. The crucible and contents were weighed. Then, it was heated in the oven at 105-110 °C for 3h. Just after removal from the oven, it was allowed to cool in a desiccator. The crucible and dried sample were weighed again. The process of heating, cooling and weighing was repeated until a constant weight was obtained (Hinojosa *et al*., 2004). To a 5 g of soil sample in a 50 mL beaker, 50 mL of deionized water was added to the sample. Then, the electrode of pH was placed in the slurry, swirled carefully and measured the pH with a pH meter.

To determine the composition of soil, a 50 g of soil sample was weighed and placed in a 500 mL conical flask. Then 125 mL of distilled water and 50 mL of 10 % sodium pyrophosphate solution were added to disperse the soil colloids and heated for 15 min and cooled down and the solution were made up to the mark with distilled water and then kept overnight to allow the soil colloids to settle. Then, the contents were stirred for about 4 min. From the residue, the percentage of clay, silt and sand were calculated (Jackson, 1958).

Determination of Heavy Metal Contents (Pb, Cd, Mn, Zn, Fe, Cu) by AAS

A 1 g of soil sample was accurately weighed and placed in a 250 mL beaker and then treated with 10 mL aliquots of high purity concentrated nitric acid. The mixture was heated to dry on a sand bath and then cooled. This procedure was repeated with another 10 mL concentrated nitric acid followed by 10 mL of concentrated hydrochloric acid. The digested soil samples were then warmed in 20 mL of 2 M hydrochloric acid to re-dissolve the metal salts. Extracts were filtered through Whatman No. 40 filter paper and the volume was then adjusted to 40 mL with deionized water. The heavy metal concentrations in the above solutions were determined by Atomic Absorption Spectrophotometeric (AAS) method.

Assessment of soil contamination

The contamination factor (C_f) was used to assess the enrichment of trace metals in the soils and to measure the pollution levels. The C_f of individual metal is the ratio of metal concentration in the soil (C_i) and the background value of the same metal (concentration of the metal in undisturbed soil, C_0). The C_f is computed using the following equation.

$$C_f = C_i/C_0$$

The degree of contamination, C_d, is defined as the sum of all contamination factors for various heavy metals. In order to facilitate the pollution control "degree of contamination

(C_d)" was proposed by Hakanson which is obtained as follows:

$$C_d = \sum C_{fi}$$

Pollution load index (PLI) is an index for evaluation of contamination status of soil samples to heavy metals. PLI is defined as follows:

$$PLI = (C_{f1} \times C_{f2} \times C_{f3} \times \ldots \times C_{fn})^{1/n}$$

Results and Discussion

Some Characteristics of Soil Samples from Heinda Mine Area

Some properties of six soil samples from Heinda mining areas such as pH, moisture and texture values were determined. pH of the undisturbed site (S_0), was 6.32. The soil from this control site was acidic. Moreover, it was found that other five sites, S_1, S_2, S_3, S_4, and S_5 have nearly neutral of pH 7. The moisture percent of control site (undisturbed soil) was the lowest, i.e., 0.11%. The location of other sites, S_1 through S_5 were in the middle of the small stream. This stream dried up in summer season, however, there were a little of water in some sites of S_1 and S_4. So these sites were found to have higher moisture percent than the others. The textural type of control site was loamy sand and those of other sites of S_1 through S_5. were sand. Table 2 shows some characteristics of soil samples from Heinda mine area.

Table 2 Some Characteristics of Soil Samples from Heinda Mine Area

Sampling Sites	pH	Moisture (%)	Texture
S_0	6.32	0.11	loamy sand
S_1	6.77	0.24	sand
S_2	6.71	0.13	sand
S_3	6.93	0.16	sand
S_4	6.91	0.40	sand
S_5	7.03	0.15	sand
Min-max	6.32- 7.03	0.11- 0.40	

Heavy Metals (Pb, Cd, Mn, Zn, Fe, Cu) Contents in Soil Sample from Heinda Mine Area

In this study, the heavy metal contents (Pb, Cd, Mn, Zn, Fe, Cu) of the six soil samples from Heinda mine area in Dawei Township, Tanintharyi Region were determined. Table 3 and Figure 2 show the levels of heavy metals in six soil samples from Heinda mine. Pb content was not detected in these six soil samples. Cd content of S_3, 0.07 ppm was the highest content, however, Cd contents in other sites, S_0, S_1, S_2, S_4 and S_5 were nearly the same i.e., 0.05 ppm, 0.04 ppm, 0.04 ppm, 0.04 ppm and 0.03 ppm, respectively. Cd contents were below the allowable limit of 0.8 ppm. Although Mn content was observed as the highest in S_1 (54.26 ppm), it was found within the allowable limit of 300 ppm. Zn contents were also found within the allowable limit of 50 ppm. The highest content of Zn, 0.77 ppm was observed in S_4 and the lowest content of Zn, 0.35 ppm was found in S_0. Fe content in S_0, 39.02 ppm, was the lowest in all soil samples, because this site is situated in undisturbed area of mining works. Cu content was observed in S_0, 0.50 ppm, but Cu content was not detected in other sites of S_1, S_2, S_3, S_4 and S_5. Pb, Cd, Mn, Zn, Fe, and Cu contents were within the allowable limits of WHO (1996).

Table 3 Heavy Metal Contents of Soil Samples from Heinda Mine Area

Sampling Sites	Heavy Metal Contents (ppm)					
	Pb	**Cd**	**Mn**	**Zn**	**Fe**	**Cu**
S_0	ND	0.05	6.04	0.35	39.02	0.50
S_1	ND	0.04	54.26	0.65	48.02	ND
S_2	ND	0.04	31.42	0.69	49.76	ND
S_3	ND	0.07	19.76	0.67	45.41	ND
S_4	ND	0.04	40.10	0.77	48.06	ND
S_5	ND	0.03	36.86	0.62	44.46	ND
Min- max	ND	0.03- 0.07	6.04-54.26	0.35-0.77	39.02-49.76	ND- 0.50
*Permissible limit	85	0.8	300	50	300	36

*WHO (1996)

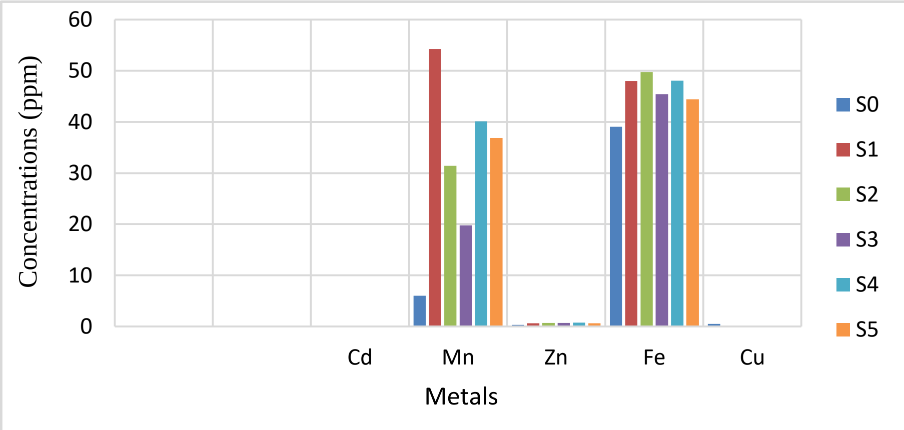

Figure 2 Heavy metal contents of soil samples in Heinda mine area

Contamination Factor (C_f), Degree of Contamination (C_d) and Pollution Load Index (PLI) for Each Sampling Site in Heinda Mine Area

For determination of metal pollution in soils, contamination factor (C_f) and degree of contamination (C_d) were used. The C_f was classified into four levels of pollution: $C_f < 1$ represents no or minimal pollution; $1 < C_f < 3$ indicates moderate pollution; $3 < C_f < 6$ indicates considerable pollution; and $C_f > 6$ indicates very high pollution (Zaigham *et al*., 2012). The range of C_f values were 0.65-1.44 for Cd, 3.27-8.99 for Mn, 1.77-2.21 for Zn and 1.14-1.28 for Fe. The results indicated that the surface soil in the Heinda mining area were moderately polluted by Zn and Fe. In contrast, Cd exhibited low concentration. However, it is noteworthy that several sampling sites showed considerable contamination of Mn and moderate contamination of Zn and Fe.

The C_d was also divided into four groups as follows: (i) low degree of contamination $C_d < 8$), (ii) moderate degree of contamination ($8 \leq C_d < 16$), (iii) considerable degree of contamination ($16 \leq C_d < 32$), and (iv) very high degree of contamination ($C_d \geq 32$) (Zorpas *et al*., 2002). The calculated C_d range of soil samples were in the range of 7.79-12.83. The results indicated that the surface soils of site 1, site 2, site 4 and site 5 in the Heinda mining area were found to be moderately contaminated. In contrast, site 3 exhibited low concentration. Pollution load index (PLI) is an empirical index that comparatively assesses the level of heavy metal pollution for each sampling site (Aydinalp and Marinova, 2004). Site 1 was the highest degree of contamination degree and highest pollution load index. The results are shown in Table 4 and Figure 3.

Table 4 The Values of Contamination Factor (C_f), Degree of Contamination (C_d) and Pollution Load Index (PLI) for Sampling Sites in Heinda Mine Area

Sampling Sites	C_f						C_d	PLI
	Pb	Cd	Mn	Zn	Fe	Cu		
S_1	ND	0.85	8.99	1.85	1.23	ND	12.83	2.04
S_2	ND	0.73	5.20	1.96	1.28	ND	9.17	1.76
S_3	ND	1.44	3.27	1.92	1.16	ND	7.80	1.80
S_4	ND	0.85	6.61	2.20	1.23	ND	10.93	1.98
S_5	ND	0.65	6.11	1.77	1.14	ND	9.66	1.68
Min-max	ND	0.65- 1.44	3.2- 8.99	1.77-2.20	1.14-1.28	ND	7.80 -12.83	1.68-2.04

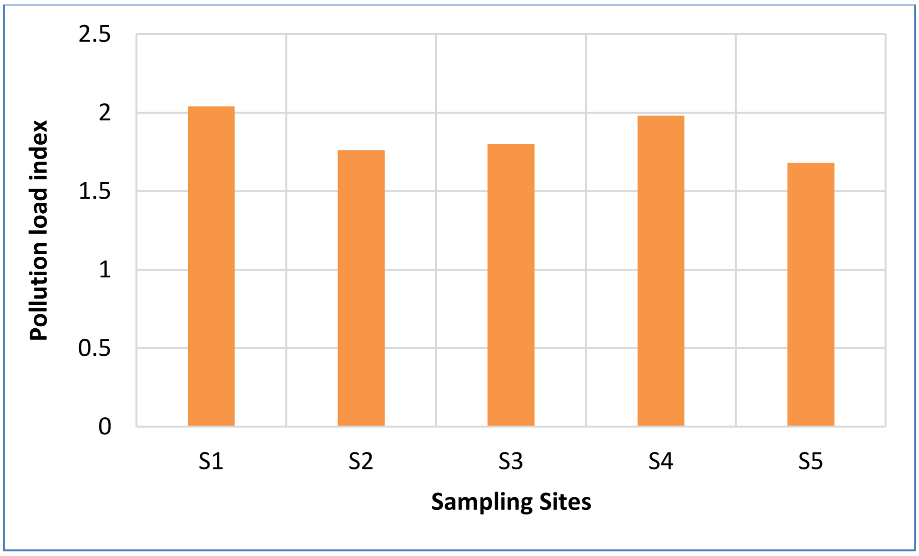

Figure 3 Pollution load index of each sampling site in Heinda mine area

Conclusion

In this research work, six soil samples were collected from Heinda mine area in March, 2019. According to the physicochemical analysis, the moisture percent of S_4, 4.4%, was the highest content. The pH values for S_0, S_1, S_2, S_3, S_4, and S_5 were 6.32, 6.77, 6.71, 6.93, 6.91 and 7.03 respectively. Soil types of S_1, S_2, S_3, S_4, and S_5 were found to be sand and S_0 was found to be loamy sand. According to the AAS results, Pb was not detected for all sampling sites. Minimum and maximum contents were observed to be 0.03 and 0.07 ppm of Cd, 6.04 ppm and 54.26 ppm of Mn, 0.35 ppm and 0.77 ppm of Zn, 39.02 ppm and 49.76 ppm of Fe and ND and 0.50 ppm of Cu. The degree of contamination (C_d) of soil samples showed site 3 < site 2 < site 5 <site 4< site 1. The pollution load index (PLI) of soil samples showed site 5< site 2 < site 3 < site 4<site 1. Based on results, site 1 and site 4 have higher C_d and higher PLI than other sites due to the accumulation of mine waste near these sites. However, the heavy metals in soil samples were under the permissible contamination levels.

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